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International Scientific Colloquium

PROCCEDINGS | **10 - 13 September 2007**

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COMPUTER SCIENCE MEETS AUTOMATION

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Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

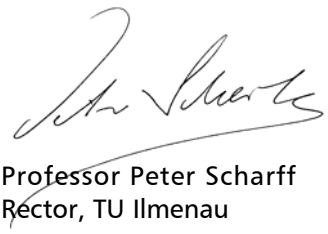
- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

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H. T. Shandiz, E. Zahedi

Noninvasive Method in Diabetic Detection by Analyzing PPG Signals

Abstract: As the report says, every 10 second 2 persons become diabetic patients. It is a medical condition caused by a lack of insulin, which makes the patient produce a lot of urine and feel very thirsty. If it is not recognized on time, blindness is one of the results of this disease. Recognizing diabetics by invasive and simple method can help the national health center to alert people. By filtering and using Kurtosis function on PPG signals a method for recognizing diabetic is proposed.

1. Introduction

Noticeable numbers of people are dying worldwide because of diabetic disease each year. The cause of this disease is due to lack of insulin or its effectiveness. The result of this disease is high level of glucose in the blood. Short and long-term complications are due to this change in glucose level. As the amount of blood volume in the figure changes, this variation can be measured by photoplethysmography (PPG). When a fixed source of infrared radiation is used, the variation of blood volume act as a phototransistor and the receive signal is changed. This is why we use the PPG signal for recognizing the diabetic.

In the following we review, the researchers try for using PPG in monitoring heath conditions of people, as an invasive method.

A. Emilio et al, use PPG signal to measure intravascular volume change and indicate the blood pleasure. They formed two groups according to age. Each group had three healthy volunteers: three males who are younger age group (24-26 years) and two males and one female for older age (58-68 years) group. They found statistically significant difference in intravascular finger compliance between the younger and older people over a range of P_{mean} from 40-60 mmHg [1].

M. Joseph et al, explored the feasibility of employing PPG and pulse oximetry to assess the status of the blood circulation in the dental pulp. Radiographic and subjective test for determination the validity of a tooth is painful and invasive [2].

A. Johansson et al, made a new respiratory device based on PPG signals. They found the respiratory signals from PPG device were compared to impedance plethysmographic signals [3].

J. Allen and A. Murray, have used signal processing algorithms to calculate beat to beat measures of pulsatility, and determined normative data for multi-site PPG pulse assessments. They collected waveforms from right and left ear lobes, thumb pads and toe pads. They measured median coefficients of variation for pulse amplitude, difference in pulse transition time [4].

V. S. Murthy et al, presented the result of the spectral analysis of PPG signals for normal and patients with various cardiovascular disorders. They show the PPG can be used to analyze cardiovascular disorder and supplement existing methods of analyzing heart rate variability [5].

K. w. Chan and Y. T. Zhang, used a LMS filter with automatic step size control to mitigate the effects of motion artificial in PPG recording for long term patient monitoring. They proof their LMS filter with variable step size has better performance than fixed step size [6].

As Kurtosis function is used in this work, briefly the normal distribution and deviation of it is

explained.
A random variable is a function in which outcome of a probabilistic experiment is its domain and real number is the range. If density function of a random variable is as follow:

$$f(x)=\frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (1)$$

In which σ is standard deviation and μ is mean of data, then it is normal [7].
The kurtosis of a distribution is defined as follow:

$$k=\frac{E(x-\mu)^4}{\sigma^4} \qquad (2)$$

It is a measure of how a distribution is deviated from normal. The kurtosis of the normal distribution is 3. Distributions that are more outlier-prone than the normal distribution have kurtosis greater than 3; distributions that are less outlier-prone have kurtosis less than 3 [8].
By putting the PPG signal in array X and using the following MATLAB command

$$k = \text{kurtosis}(X) \qquad (3)$$

The deviation from normal in signal is measured.

2. Data acquisition

There are two array groups of PPG signals. Pathologic arrays contain data from all subject tested in the hospital who were diabetic (39-64 years ages). Healthy arrays contain all data from healthy subjects (22-52 years old). Figure 1 shows a recorded PPG signal for a diabetic patient.
In each file, the only variable is a (50x24750) which is the raw PPG data:

- Each row is one particular lead.
- First column: subject number: Sb
- Second column: lead number: Ld
- Third column: Age
- Fourth column up to end: raw PPG data
- The length of the files has been limited to 90 sec (sampled at 275 Hz, this gives 24750 sample points)
- The number of rows (records) has been limited to 50 per file to limit file size
- The format of the data is uint32 to save on space.

3. Signal processing and result

Some parts of the PPG signal may be affected by motion artifact noise, which is due to the movement of the probe. In order to avoid these episodes, it is necessary to inspect the signal visually and select that part of the signal that is "stable". Our experience shows a length of about 1000 samples seems sufficient to extract the value of the Kurtosis or negentropy.
Then the dc level of signals are removed and data are normalizing between ± 12. As the PPG signal that is recorded may contain noise and baseline drift, it is good to preprocess it using a band pass filter. It has to be FIR type to conserve the shape. As our experiences show, the recommended values for the BPF are 0.6 Hz to 15 Hz. The original sampling frequency of the data was 275 Hz. Figure 3 shows the frequency characteristic of the filter. The result of applying this filter to data in figure 2 is representing in figure 4. Figure 5 shows the result for healthy and patient data.

4. Conclusion

The result of applying Kurtosis function on filtered selected real data shows the Kurtosis for patient is around 20.6 while for healthy is 20 and under. For healthy people the accuracy of the

method is about %85 and for patient is about %76.

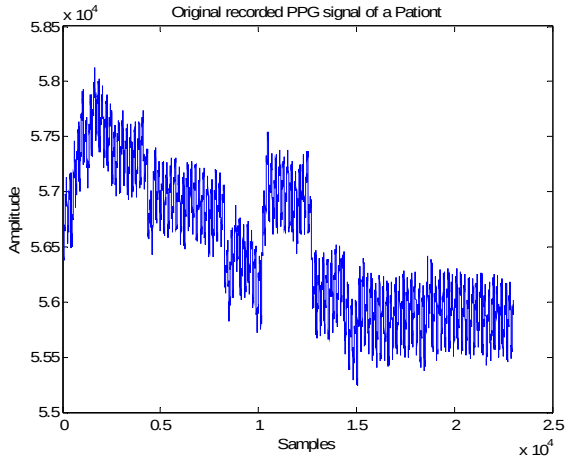


Figure 1. A patient recorded PPG signal

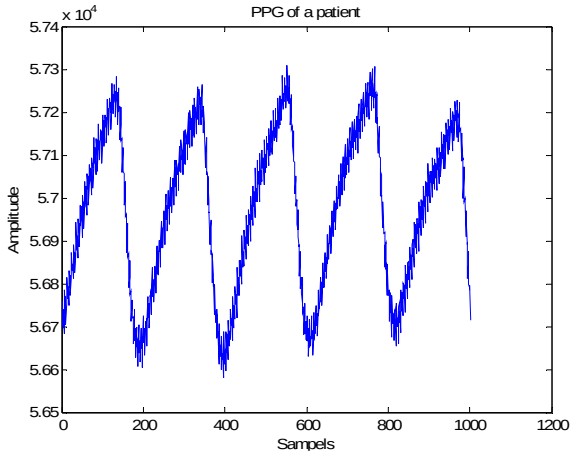


Figure 2. One stable part with 1000 samples of figure 1

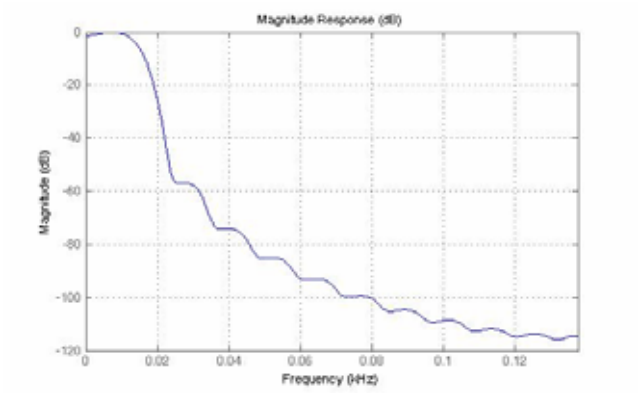


Figure 3. Frequency domain characteristics of BP filter

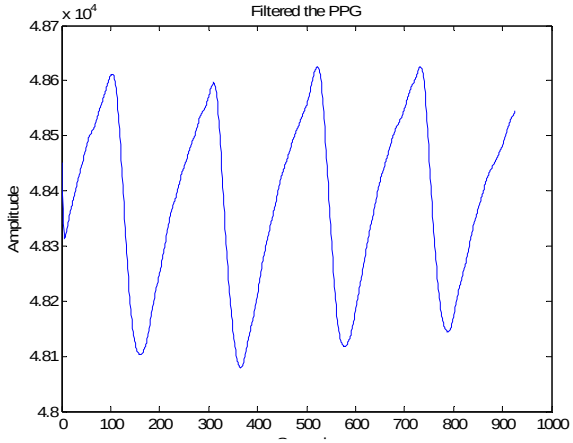
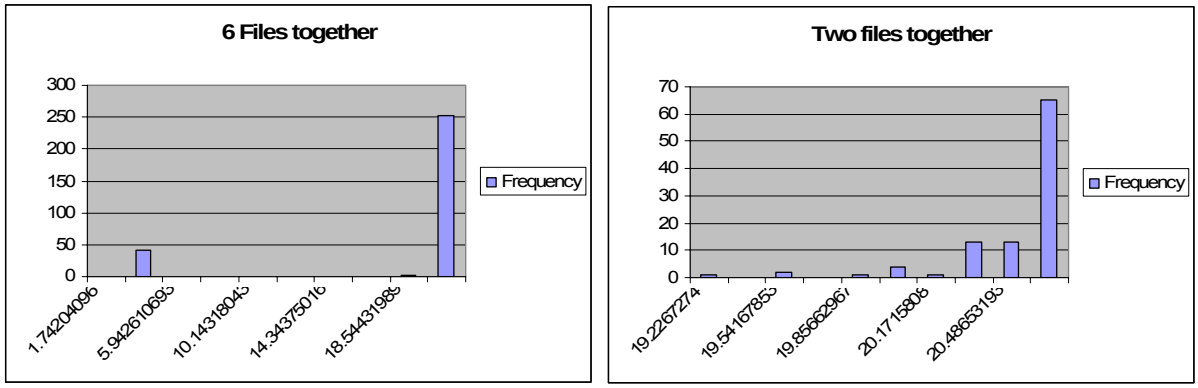


Figure 4. Filtered data in Figure 2



(a) (b)

Figure 5. Kurtosis function: a) Healthy and b) Diabetics people

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Authors:

Dr HEYDAR TOOSSIAN SHANDIZ
Dr EDMOND ZAHEDI

Shahrood University of Technology, Electrical Engineering
Faculty
7 Th Tir Square, P.o.Box 36155-316, Shahrood, IRAN

36155-316, Shahrood
Phone: 0098-9121733733
Fax: 0098-273-3334419
E-mail: htshandiz@shahroodut.ac.ir or
h_t_shandiz@hotmail.com